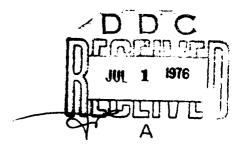


Report 2164

SILICONE BRAKE FLUIDS: TWO-YEAR FIELD TEST

January 1976

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U.S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT COMMAND
FORT BELVOIR, VIRGINIA

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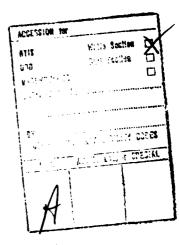
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SILICONE BRAKE FLUIDS: TWO-YEAR FIELD TEST

1. INTRODUCTION

The Army uses three types of automotive hydraulic fluids. These are covered by Specifications VV-B-680, "Brake Fluid, Automotive," for operations ranging from plus 55°C to minus 30°C; MIL-H-13910, "Hydraulic Fluid, Polar Type, Automotive, All Weather," for operation to minus 55°C; and MIL-P-46046, "Preservative Fluid, Automotive Brake System and Components," for brake systems of vehicles in storage and as a packaging fluid for wheel and master cylinders.

In 1967, because of the success of silicone fluids in hydraulic applications, makers of these fluids became interested in developing a single all-purpose fluid to overcome the water sensitivity of current fluids as well as to provide all-weather and preservative properties. The producers were encouraged to develop such a fluid since it would reduce maintenance and logistics costs substantially by providing increased brake system reliability; eliminating the need to change fluids for CONUS, Arctic, or storage conditions; and replacing the three existing fluids with one. During the next three years, deficiencies such as poor lubrication properties and rubber incompatibility which showed up in laboratory testing were lessened by the incorporation of small amounts of additives to the fluids. Laboratory evaluation, including stroking tests based on SAE specifications and storage tests for packaging and preservative properties, established that a sificone fluid could be formulated to provide heavy-duty and arctictype performance and the preservative properties required by the current brake fluids and packaging fluid. The remaining question of suitability under all operating conditions required the conduct of a field test. During March and April 1973, therefore, tests were initiated to obtain experience with silicone fluids in operational vehicles

Three silicone fluids (two water-intolerant and one water-tolerant) and a conventional specification fluid were installed in the brake systems of vehicles operated by Army units in three areas representing climatic extremes: tropical (Tropic Test Center, Panama Canal Zone); extreme cold (Arctic Test Center, Fort Greeley, Alaska); and desert (Yuma Proving Ground, Arizona).

The first year inspection was covered in USAMERDC Report 2132.* This portion of the test showed that the silicone brake fluids will equal or exceed the performance obtained from current specification fluids. The most significant improvement was found in Panama where numerous malfunctions due to corrosion occurred with brake systems using the specification fluid. There were no malfunctions with the silicone brake fluids.

James H. Conley, Robert Jamison, and Charles B. Jordan, "Silicone Brake Fluids: One-Year Field Test," USAMERDC Report 2132, AD A012849 (Feb 75).

In Yuma the general appearance of the systems with silicone fluids was somewhat better than those with the conventional fluids. However, no malfunctions occurred which were attributable to the fluids.

The same situation held true for the Alaskan portion of the test where the performance of the system which was operated with the silicone shid for one year was comparable to those systems with the specification fluid.

This report contains the final results of the two-year field test of silicone brake fluids operating at TTC and YPG and the one-year test of two low-temperature fluids operating at ATC.

H. DETAILS OF TEST

Three silicone fluids (two water-intolerant and one water-tolerant) and a conventional specification fluid (VV-B-680) were used in Panama and Yuma. These silicones were used initially in Alaska. Testing on the water-intolerant fluids was discontinued midway through the test, however, because of possible crystallization at temperatures below minus 46°C (50°F), and two new silicones with improved low-temperature properties were substituted and compared to conventional MIL-II-13910 arctic brake fluid.

For these tests, new brake cylinder sets were packaged with fluid in the laboratory and shipped with new brake hoses to the appropriate area for installation on M 151, ¼-ton cargo vehicles and M 715, 1¼-ton vehicles. After one year, half the cylinders from Panama and Yuma were torn down on site and examined for condition of the metal parts and rubber compounds and for appearance of the fluid. Samples of the fluids were sent back to the laboratory. The cylinders were then reinstalled and brought back to level with fresh fluid, and the vehicles were returned to operation. Cylinders of the other vehicles were left undisturbed. After two years' operation all cylinders, hoses, and samples of the fluid were returned to the laboratory for final evaluation. In Alaska, all cylinders were returned for examination after one year's operation. In addition to visual examination of the fluids, water pick-up was determined by the Karl Fisher Method.

III. DISCUSSION

In Panama (Table 1), three of the four vehicles using the VV-B-680 fluid completed the second year of operation without a brake malfunction (numerous failures occurred during the first year) even though the cylinders were severely corroded. The fourth vehicle was reported missing in February 1975, and no data are available. During examination of the brake parts, a strong odor of gasoline and swelling of the

Table 1. Panama Inspection

Ami's along a	Pluid	Inspection Date/	Total	Visual Inspection	tion	Fluid Appearance	e e febrer
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Columbers
HQ-7 1:SA2A055369	VV-B-680	May 75/24	3980	Cylinder bore - satisfactory	All cylinders-heavy rusting under pistons	Moderate sediment	Moderate-to- heavy sediment
%-Ton				Piston-satisfactory		5 H to 10.4	:
•				Spring-satisfactory	Pistons—heavy rust and gum		4 H ₁ 0 5 .
				Secondary Cup-slight	Cups-light scuffing		E.91
				scuffing	All soringsslight		
				Primary Cup-slight scuffing	Tustirg.		
НО-37	VV-B-680	May 75/24	3084	Cylinder-heavy rusting	Cylinders 1 wheel	Slight sediment	Heavy sediment
USA03M83668				under secondary cup	cyfinder ficavy rust under both pistons	Gasoline odor	9 H20 - 11.6
				Piston-satisfactory	•		8.4
					1 wheel cylinder	7.H ₂ 0 5.3	10.1
				Secondary cupslight	heavy rust under I		7
				scuffing; appears to be	piston; slight-to-		
				swollen; hard to remove	moderate rusting		
					under 1 piston		
				Primary cup-slight scuf-			
				fing; odor of gasoline	2 wheel ev linders—		
					moderate rusting		
					under both pistons;		
					more under cups		
					Pistons 3 pistons		
					heavy gumming; 3		
					Distons moderate: 2		
					pistons light		
					gumming		
					Cups-2 moderate; 6		
					light scuffing		
				!	Springs- satisfactory		

Table 1. Panama Inspection (Cont'd)

and Type HQ-38 1 SA03MB2568 24-Ton		Months of	Total	Visual Inspection	tion	Fluid Appearance	prafance
N82568	307	Yenice	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
* *	0 9 - D- 0 9 0	May 75/24	1829	Cylinder heavy rusting under secondary cup	Cylinders - heavy rusting under pistons	Slight sediment	Moderate to- heavy sediment
				Piston sabsfactors	in 3 cylinders; moderate moting	Gasoline odor	6 G G G
					under pistons in 1	% H ₂ 0 6.8	
				Spring satisfactors	wheel cylinder		5.3 10.5
				Secondary cup slight	Pistons heavy rusting		
				scuffing; appears to be	and gumming on piston		
					moderate rusting and		
				Primary cup- moderate	gumming on pistons in		
				scuffing; light scoring at base	I wheel cylinder		
				Gasoline odor	Cups- slight scuffing		
HQ-21 (*,C.	.;	May 75/24	2100	Cylinder - satisfactory	Cylinder-satisfactory	Slight sediment	Slight sediment
CSAUZAJIWO 94-Ton				Piston -satisfactory	Pistons -satisfactory	% H ₂ 0: 0.5	% H ₂ 00.0
*				Spring - satisfactory	Springs satisfactors		- 0, 8 5 6
				Secondary cup-satisfactory	Cups- light scuffing		
				Primary cup- slight scoring			
HQ-40 USA03M86468	. ;	May 75/24	189	Cylinder- satisfactory	Cylinder-satisfactory	Clear	Clear
1/4-Ton				Piston-satisfactory	Piston-slight scoring	Gasoline odor	% H ₁ 0-0.0 0.1
				Secondary cup—slight	39 34 31 33	% H ₂ 0~0.3	0.0
				e culling.	Cups—signt sculling and scoring		
				Primary cup- moderate scoring and scuffing over secondary port; both cups swollen	Springs-satisfactory		

Table 1 Panama Inspection (Cont'd)

Visual Inspection Visual Inspection Wheel Cylinders Mater Cylinder Wheel Cylinder Mater Cylinder Wheel Cylinder Mater Cylinder Springs-satisfactory Springs-satisfactory Cylinder normal wear Cear			Inspection					
Name Secure Wheeler (Shinders Wheeler (Shinders Wheeler (Shinders Name Struct	Vehicle Number	Flad	Months of	Total	Visual Inspec	tion	Huid App	bratance
1.C. May 75/24 3150 (A) Inder-satisfactory Springs-satisfactory Springs and receiver Springs and receiver Springs and receiver Springs and cheek-valve satisfactory springs in center bottom with normal wear in pistom Spring and cheek-valve sarias and moderate scuffing in center bottom with normal wear in pistom Spring and cheek-valve sarias Springs springs in center bottom with sectings Springs and cheek-valve sarias Springs	and Libra		Serie	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
Picton - satisfactory Picton - satisfactory Springs - satisfactor	HQ-29 USA03M00968	1.0.	May 75/24	5150	Cylinder -satisfactory	Cylinder normal wear	Char	Chrat
Securing Serifing Springs-studenting ("aps-shight serifing serifing serifing serifing serifing serifing; both cups swellen serifing; both cups swellen serifing; both cups swellen ("Alia 75/24 4747" ("Aliadra-satisfactor cylinders-2 wheel ("Tear Secondary cup-satisfactor cylinders show heavy corrosion in center of "Bi-0.00 portion with normal wear in piston and moderate serifing in center bottom with normal wear in piston slight corrosion and needs are serious; 4 normal wear in piston stight corrosion serifing; 3 sheel ("Character Serifing;	1%-Ton				Piston-satisfactory	Pistons - slight scoring	Gasoline odor	4.1 o.14 %
Springs-stitifactor setfing; both cups wollen BLC. May 75/24 4747 Cylinder-satisfactory cylinders-2 wheel Clear Secondary cup-satisfactory cylinders show when year in picton are: Secondary cup-satisfactory cylinders show with normal Secondary cup-satisfactory cylinders show sight corrosion Spring and moderate scuffing increment in picton with Spring and check valve - area slight corrosion Spring and check valve - area slight corrosion D.C. May 75/24 3718 Cylinder-overall staining cylinder satisfactory Secondary cup-satisfactory Springs-satisfactory Springs-satisfactory Springs-satisfactory Springs-satisfactory Strings-satisfactory Strings-satisfa					Secondary cup alight	Cupsslight scuffing	CH ₂ 0 00	?i
D.C. May 75/21 4747 (Sylinder-satisfactory cylinders-2 wheel Glear Staton - satisfactory Piston - satisfactory corrosion in center of May 0.0.0 Portions with normal Secondary cup - satisfactory corrosion in center bottom with normal and moderate scuffing in center bottom with normal wear in piston satisfactory ship in center bottom with normal wear in piston and check valve - sight corrosion Spring and check valve - secondary corrige; 3 slight corrosion slight corrosion Pistons - I moderate scoring; 3 slight secondary cup - satisfactory Springs - Secondary cup - satisfactory Springs - Secondary cup - satisfactory stain in center Secondary cup - satisfactory stain in center Secondary cup - satisfactory spain in center Secondary cup - satisfactory cylinder) shight scoring cylinder)					Primary cup slight scuffing: both cups swollen	Springs satisfactors		
Paton - satisfactory common in center 1 (* 18, 0 - 0.0) Secondary cup - satisfactory were in piston area: Primary cup - slight scoring show slight corrosion and moderate scuffing normal wear in piston spring and check valve - area slight corrosion slight corrosion alight corrosion spring and check valve - area slight corrosion slight corrosion spring and check valve - area slight corrosion slight corrosion springs - area slight corrosion staining conjug. 4 normal wear in piston series area slight corrosion staining cylinder-a suisfactory pitchers as a staining cylinder-a suisfactory serion satisfactory stain in center series corring series corring series corring cylinder satisfactory stain in center series corring series corring series corring cylinder series corring series corring cylinder cylinder series corring cylinder	HQ-8	D.C.	May 75/24	11.21	Cylinder- satisfactory	Cylinders—2 wheel	Clear	Moderate
Secondary cup: satisfactors wear in piston area: 2 where of indexing and moderate scuffing in center bottom with normal wear in piston Spring and check valve - slight corrosion and moderate scuffing in center bottom with normal wear in piston Spring and check valve - slight corrosion and moderate scoring: 3 slight scoring: 3 slight scoring: 3 slight scoring: 3 slight scoring scoring: 3 slight scoring scoring: 3 slight scoring still cylinder—overall staining cylinder—a wheel cylinder satisfactory stain in center scoring: 3 slight scoring cylinder) slight scoring cylinder] Secondary cup—satisfactory stain in center scoring cylinder] slight scoring cylinder]	/+Ton				Piston- satisfactors	corrosion in center	% W ₂ 0 0.0	*
Secondary cup - satisfactory Primary cup - slight scring and moderate scuffing and moderate scuffing and moderate scuffing in center bottom with normal wear in piston Spring and check valve - area slight corrosion Spring and check valve - securing: 3 slight securing: 3 slight securing: 7 slight scuffing Springssatisfactory Springesatisfactory Springesatisfactory Sprinder - 3718 Secondary cupsatisfactory Sprinder - 3 wheel Spring - 3718 Springsatisfactory Spring - 3 slight scoring						bottom with normal		9. H ₂ 0. 0.0
Primary cup - slight scoring show slight corrosion and moderate scuffing in center bottom with normal wear in piston Spring and check valve - area slight corrosion Spring and check valve - area slight corrosion Pistons - I moderate scoring: 3 slight scoring in center bottom with normal wear in piston Spring and check valve - area storing: 7 slight scoring cylinder-a wheel clear cylinder-a wheel clear cylinder satisfactory: Biston satisfactory slain in center series corring cylinder) slight scoring cylinder) slight scoring cylinder) slight scoring cylinder) slight scoring					Secondary cup satisfactors	wear in piston area; 2 wheel extinders		0 0 0 0
and moderate scuffing in center bottom with Spring and check valve - area slight corrosion Pistons - I moderate scoring: 3 slight scoring: 3 slight scoring: 4 normal wear Cups - I moderate scoring: 7 slight scoring: 7 slight scuffing D.C. May 75/24 3718 (5/linder—overall staining cylinder—3 wheel Clear Secondary cup—satisfactory stain in center Secondary cup—satisfactory Pistons - 2 (1 wheel Primary cup—slight scoring cylinder) slight scoring					Primary cup -slight scoring	show slight corrosion		0.0
Spring and check valve - area slight corrosion Pistons I moderate scoring: 3 slight					and moderate scuffing	in center bottom with		
slight corrosion Pistons - I moderate scoring; 3 slight scoring; 3 slight scoring; 3 slight scoring; 3 slight scoring; 7 slight scuffing Springs—satisfactory Piston satisfactory stain in center Secondary cup—satisfactory Pistons - 2 (1 wheel Primary cup - slight scoring Pistons - 2 (1 wheel Primary cup - slight scoring						normal wear in piston		
Pistons I moderate scoring; 3 slight scoring; 3 slight scoring; 3 slight scoring; 3 slight scoring; 4 normal wear Cups-1 moderate scuffing; 7 slight scoring Springs-satisfactory Springs-satisfactory Springs-satisfactory Piston satisfactory Piston satisfactory Pistons-2 (1 wheel Stain in center Secondary cup-satisfactory stain in center Serondary cup-satisfactory stain in center Serondary cup-satisfactory pistons-2 (1 wheel Primary cup-slight scoring cylinder) slight scoring					Spring and check valve a slight corrosion	2772		
scoring; 3 slight scoring; 4 normal wear Cups-1 moderate scuffing; 7 slight scuffing; 8 slight scuffing; 9						Pistons 1 moderate		
Springs - satisfactory D.C. May 75/24 3718 Cylinder overall staining Cylinder satisfactory: Piston satisfactory stain in center Secondary cup - satisfactory Pistons - 2 (1 wheel Primary cup - slight scoring cylinder) slight scoring						scoring: 3 slight		
Cups-1 moderate scuffing; 7 slight scuffing, 7 slight scuffing and 75/24 3718 Cylinder-overall staining Cylinder-3 wheel Clear cylinders satisfactory; Piston satisfactory stain in center Secondary cup-satisfactory Pistons -2 (1 wheel Primary cup-slight scoring cylinder) slight scoring						Sconnk: 4 normal		
D.C. May 75/24 3718 Cylinder—overall staining Cylinder—3 wheel Clear cylinders attisfactory: Piston satisfactory I wheel stain in center Secondary cup—satisfactory Pistons—2 (1 wheel Primary cup—slight scoring cylinder) slight scoring						Cups-1 moderate scuffing; 7 slight scuffing		
D.C. May 75/24 3718 Cylinder-overall staining Cylinders satisfactory: Piston satisfactory I wheel Clear Secondary cup—satisfactory Pistons—2 (1 wheel Primary cup—slight scoring cylinder) slight scoring						Springs-satisfactory		
Piston satisfactory I wheel cylinder % H ₂ 0-0.0 % H ₂ 0- Secondary cup-satisfactory Pistons - 2 (1 wheel Primary cup-slight scoring cylinder) slight scoring	HQ-17 USA250738	D.C.	May 75/24	3718	Cylinder—overall staining	Cylinder—3 wheel cylinders satisfactory;	(:lear	Slight sediment
Secondary cup—satisfactory Pistons -2 (1 wheel Primary cup—slight scoring cylinder) slight scoring	%-Ton				Piston satisfactory	I wheel cylinder	% H ₂ 0-0.0	% H, 0-0.5
	*				Secondary cup-satisfactory			G (5)
					Primary cup slight scoring	Pistons 2 (1 wheel cylinder) slight scoring		

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Panan
Table

Spring and three valve to normal wear slight-to-moderate curesion corresion corresponding corr	Vehicle Number	Fluid	Inspection Date; Months of	Total	Visual Inspection	chon	Fluid Ap	Fluid Appearance
Continued Spring and chreb valve Copperate Cop	and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
Springs satisfactory Springs statefactory Springs satisfactory	HQ-17 (Continued				Spring and check valve slight-to-moderate	6 normal wear		
Springs satisfactory Springs satisfactory Springs satisfactory Cylinders. 2 sates Cylinders. 2 sates Cylinders. 2 sates Cylinders. 2 sates Cups swollen; secondary Beton satisfactory Spring swollen; secondary Spring satisfactory	1.5.4230.30 1. Ton				cortosion	Cups. all slight		
D.C. May 75/24 1378 C.Minder-satisfactory C.Minder-2 satis- Clear Clear						scuffing		
D.C. May 75/24 1378 Cylinder-satisfactory Cylinder-2-site- Gear Clear						Springs satisfactory		
Mu2108 Piston -satisfactory dight to crossion in Gasoline (doir (*1H ₂ 0) button criter Cups swollen; secondary button criter Cups swollen; secondary button criter Strong odor of gasoline wear present Cups satisfactory Springs satisfactory Springs -satisfactory Cylinders Juper Cylinders Cylinder	HQ-27	D.C.	May 75/24	1378	Cyfinder-satisfactory	Cylinders 2 satis-	Clear	Clear
Cups swollen; secondary hottom cruter (9 H; 0 0.5) Cups swollen; secondary hottom cruter (9 H; 0 0.5) Fistons 2 moderate (9 H; 0 0.5) Spring satisfactory Spring satisfactory Springs satisfactory Springs satisfactory (1) moder satisfactory (2) moder satisfactory (2) moder satisfactory (2) moder satisfactory (3) moder (4) moder (4) moder (4) moder (4) moder (4) moder (4) moder satisfactory (4) moder (4) moderate (4) moderat	USA03M02168					factory, 2 show	1	
Cups swollen; secondary had to be forced out scoring; 6 normal Strong odor of gasoline N74468 D.C. May 75;24 10,733 Spring—satisfactory Piston: satisfactory Spring—satisfactory Spring—satisfactory Spring—satisfactory Outper splight pitting Outper splight pitting Outper splight pitting Outper splight pitting Outper splight southing N74468 Strong odor of gasoline Spring—satisfactory					Piston satisfactory	shght corrosion in hottom center	casoline odor	0.0 0.0
String odor of gasoline wear String -satisfactory Spring -satisfactory Spring -satisfactory Spring -satisfactory Spring satisfactory Cylinders J wheel Cylear Cylinders J wheel cylinder slight Cups - swollen: secondary Spring storing at outside had to be forced out wheel cylinder— Strong odor of gasoline Spring - satisfactory Springs satisfactory					Cups swollen; secondary		% H, 0, 0.5	0.3
Strong odor of gasoline wear present Cups satisfactory Springs satisfactory Springs satisfactory Springs satisfactory Springs satisfactory Cylinders 1 wheel cylinder Odor Piston satisfactory Cups swollen: serondary Strong odor of gasoline Strong odor of gasoline Spring satisfactory					had to be forced out	Pistons-2 moderate	•	0.0
Spring—satisfactory						scoring; 6 normal		
Spring - satisfactory Springs satisfactory Springs satisfactory Springs satisfactory Springs satisfactory Spring - satisfactory Spring - satisfactory Cylinder slight pitting on bottom center; 1 Cups - swollen: secondary wheel cylinder slight Cups - swollen: secondary secring at outside (c. H., 00.0) had to be forced out wheel cylinder. Strong odor of gasoline satisfactor Spring - satisfactory Spring - satisfactory Springs - satisfactory					Strong odor of gasoline	weat		
Spring–satisfactory Spring–satisfactory N74408 N74408 N74408 N74408 N74408 N74408 N74408 N74408 Piston–satisfactory Cylinder light titing On bottom center; I Gasoline Odor (# H, 0- had to be forced out seroing at outside (# H, 0-0.0) had to be forced out seroing at outside (# H, 0-0.0) Strong odor of gasoline satisfactory Spring–satisfactory Spring–satisfactory Springs–satisfactory Springs–satisfactory Springs–satisfactory Springs–satisfactory Springs–satisfactory Springs–satisfactory					present			
Springs satisfactory Springs satisfactory N74408 N74408 Piston satisfactory Cylinder slight pitting Piston satisfactory Cupsswollen: secondary Storing at outside Cupsswollen: secondary Storing codor of gasoline Spring-satisfactory Spring-satisfactory Springs-satisfactory						Cups satisfactory		
D.C. May 75/24 10,733 C. Linder - satisfactory C. Linder - satisfactory C. Linder - satisfactory C. Linder - satisfactory C. Linder slight pitting					Spring-satisfactory	•		
D.C. May 75/24 10,733 Cylinder-satisfactory Cylinder slight pitting Piston- satisfactory on bottom center; 1 Gasolme Odor (# H ₂ 0- Wheel cylinder slight Cupsswollen: secondary secring at outside (# H ₂ 0-0.0 edge of one end; 2 wheel cylinder Strong odor of gasoline satisfactory Pistons-5 slight scuffing; 3 satisfactory Spring-satisfactory Springs-satisfactory Springs-satisfactory Springs-satisfactory						Springs satisfactory		
Piston- satisfactor, or bustom center; I Gasoline Odor (# H, 0- Cups-swollen; secondary scoring at outside (# H, 0-0.0 had to be forced out edge of one end; 2 wheel cylinder— Strong odor of gasoline satisfacto Spring—satisfactory Pistons—5 moderate scoring 3 normal wear Cups—5 slight scuffing; 3 satisfactory Springs-satisfactory Springs-satisfactory	HQ.35	P.C.	May 75/24	10,733	Cylinder-satisfactory	Cylinders I wheel	Clear	Clear
wheeley finder slight (tups-swollen: secondary scoring at outside (e. H ₂ 0-4).0 had to be forced out edge of one end; 2 wheeley linder— Strong odor of gasoline satisfacto. Spring-satisfactory Pistons—5 moderate scoring 3 normal wear (cups—5 slight scuffing; 3 satisfactory satisfactory springs-satisfactory	1 S 405 M : + + 08				Piston, setisfactor	on bottom center: 1	Gasoline Odor	6 H. 0-0.1
secring at outside (c H ₂ 0 -0.0 edge of one end; 2 wheel cylinder—satisfacto Pistons—5 moderate scoring 3 normal wear Cups—5 slight scuffing; 3 satisfactory Springs—satisfactory	1/4:101					wheel ev finder slight		0.0
edge of one end; 2 wheel cylinder— satisfacto Pistons—5 moderate scoring 3 normal wear Cups—5 slight scuffing; 3 satisfactory Springs—satisfactory	*				Cups swollen: secondary	scoring at outside	9. H ₂ 0 -0.0	0.0
					had to be forced out	edge of one end: 2	•	6.3
						wheel cylinder—		
					Strong odor of gasoline	satisfacto		
Cups—5 slight scuffing; 3 satisfactory Springs satisfactory					Spring-satisfactory	Pistons—5 moderate scoring 3 normal wear		
Cups5 slight scuffing; 3 satisfactory Springs satisfactory								
3 satisfactory Springs -satisfactory						Cups-5 slight scuffing:		
Springs satisfactory						3 satisfactory		
						Springs satisfactory		

Table i. Panama Inspection (Cont'd)

Company of the Compan

,	1	Inspection Date/	- T	=		-	
vencie Number and Type	r (m)	Months of	l otal Mikage	Master Cylinders	Thon Wheel Cylinders	Master Colinders Wheel	Wheel Cylinders
HQ.1 USA250771 %-Ton	G.F.	May 75/24	3245	Cylinder bores satisfactory Piston satisfactory Spring moderate corrosion Secondary cup satisfactory Primary cupsishin scuffing	2 Wheel Cylinders slight stain: I wheel cylinder slught stain at one end; moderate stain at the other end. I wheel cylinder heavy rust both ends and center. 2 Pistons slight stain and scoring; 4 pistons moderate stain; 2 pistons heavy corrosion I Spring, satisfactory; 2 spring, heavy rust; I spring, heavy rust; I spring, moderate rust	Sight sediment Clear 5/ H, 0/ 1,5	Moderate sediment Amber % H ₂ 0 6.7 E8 0.4 U.3
HQ.2 USA256730 %-Ton	6.E.	May 75/24	5328	Cylinder bore—moderate scoring left bottom Piston- satisfactory Secondary cup- satisfactory Primary cup-satisfactory Spring- heavy corrosion	2 Cylinders—heavy rust both ends; 1 cylinder heavy rust one end; 1 cylinder—moderate rust and stain both ends. Cups—satisfactorv. 2 Springs—heavy corrosion; 2 springs—springs—springs—springs—slight corrosion.	Beav sediment C. H. 0. 4.7	Heav sediment (c.H.) 0.5 0.5 0.0 4.2
HQ.31 USA03M56068 1¼-Ton		May 75/24	2766	Cylinder heavy rusting at secondary Piston satisfactory Secondary cup- heavy scuffing	All cylinders—heavy rust in piston area All pistons—heavy corrosion Cups—4 moderate scuffing: 4 slight scuffing	Slight sediment 9. H ₂ 01.9	Moderate sediment % 112 0 3.2 0.7 1.6 1.6

Table 1 Panama Inspection (Cont'd)

the structure of the st

Vehiele Number	Fluid	Inspection Date/ Months of	Total	V isual Inspection	tion	Fluid Appearance	Parance
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
HQ-31 (Continued) USA03M56068 1%-Ton				Primary cup—slight scuffing and scoring	Springs-moderate rusting		
				Spring - satisfactor,			
HQ-36 USA03M82668	G.E.	May 75/24	4753	Cylinder-slight rusting in secondary cup area	Cylinder-3 heavy rust both ends, 1	Black	Heav sediment
1%-Ton				•	moderate rust both	Gasoline Odor	CH10 6.2
				Piston covered with	cnds		3.0
				black residue		7.11,0.2.1	1.3
					Pistons 3 heavy		1 '0
				Secondary cup slight	corrosion: 4		
				scuffing	moderate corrosion; l		
					light corrosion		
				Primary cup-slight			
				scuffing	Cups-slight scuffing		
					and scoring		
				Spring-completely			
				detinned	Springs-slight		
					corrosion; 4 boots show polymer buildup		

^{*} Vehicle inspected at one year. New fluid added.

secondary cup were noted in the master cylinders from the two 1¼-ton vehicles. Water pick-up in the fluid ranged from 2.5 to 15 percent.

The vehicles using the silicone fluids continued to operate trouble free during the second year. The cylinders with the Union Carbide (U.C.) and Dow Corning (D.C.) water-intolerant fluids were satisfactory, with the latter showing a tendency to stain and have slightly more corrosion of metal parts. The cylinders with the General Electric (G.E.) water-tolerant fluid showed considerably more corrosion than those with other silicone fluids but were still substantially better than those with the VV-B-680 fluid. The odor of gasoline and swelling of the secondary cup in the master cylinder were also noted in the 1½-ton vehicles using the U.C. and D.C. fluids. It was not present in the vehicles using the G.E. fluid. The rubber cups had a slight-to-moderate scoring and scuffing with all the fluids under test.

In an investigation to determine the cause for the gasoline odor in the master cylinders of some of the 1½-ton vehicles, test personnel learned from TTC personnel that the affected vehicles had been equipped with deep water fording kits. These kits vent the master cylinder into the air breather which, in turn, allows gasoline vapors to enter the master cylinder and cause the rubber cup swelling that was noted.

At Yuma Proving Ground, Arizona, all vehicles except one containing U.C. silicone fluid completed the second year of operation without a brake malfunction. Those brake parts were discarded inadvertently and the cause of malfunction could not be determined. Fluid performance was comparable to the Panama portion of the test. Visual inspection and pertinent data are shown in Table 2.

At Fort Greeley, Alaska, the vehicle containing MIL-H-13910, Arctic Brake Fluid, showed heavy corrosion of the wheel cylinders and scoring of the pistons. All the vehicles with the water-intolerant silicones gave comparable results, showing only slight stain of the cylinders and, with the exception of one vehicle using the D.C. fluid, showed no piston scoring (Table 3).

Photographs illustrating representative cylinders from each climatic area are shown in Figures 1 through 8.

Table 2. Yuma Inspection

A district	Einig	Inspection Date/ Months of	Total	Visual Instruction	woi	Fluid Annearance	Falance
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
SP-208 03R00469 1½-Ton	VV-B-680	Oct 74/18	9869	No master cylinder returned	All cylinders show very heavy rust and corrosion All pistons show		Heavy sediment % H ₂ 0-5.1
					All cups—slight scuffing		
03J02268 1½-Ton *	VV-B-680	Apr 75/24	4255	Moderate-to-heavy rust at bottom of cylinder bore Rust in reservoir	All cylinders show heavy rust and corrosion	Heavy sediment % H ₁ 0-3.2	Heavy sediment % H ₂ 03.9 3.0
				Secondary cup-heavy scuffing	All pistons—heavy corrosion and gum deposit		9.3 3.3
				Primary cup-heavy scuffing	Cupsmoderate scuffing		
				Piston-satisfactory Spring-detinned	Springs—2 satisfactory; 2 detinned		
MS-6 2J8585 ½-Ton	VV-B-680	May 75/24	6908	Cylinder-moderate stain at forward end of bore	All cylinders show heavy rusting	Moderate sediment % H ₂ 03.7	Two drops recovered
•				Piston-satisfactory Secondary cup-heavy scuffing	All pistons show heavy gumming All springs—detinned		% H ₂ 0- 5.8 11.5
				Primary cup-heavy scuffing			
				Spring-satisfactory			

Table 2. Yuma Inspection (Cont'd)

	2	Inspection Date/				¥ 3	
vehicle Number	rluid	Months of	Iotal	visual inspection	tion	r ind Appearance	carance
and Type		Service.	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
MS-2 2K6397 8-Ton	VV-B-680	May 75/24	5116	Cylinder showed slight sludge	All cylinders-heavy rust and corrosion	Reavy sediment % H. 0 - 3.0	Moderate
				Piston-satisfactory	All pistons—heavy		% H ₂ 0-4.5
				Secondary cup-moderate scuffing	gumming		8.8. 4.5.6.
					All cups-slight-to-		
				Primary cup—slight scuffing and scoring	moderate scuffing		
					All springs-detinned		
				Spring-partially detinned			
03]43568 1½-Ton	U.C.	Vehicle turned in for	3347+	Cylinder-satisfactory	Left front cylinder- slight stain	Moderate sediment	Slight sediment in two wheels,
		salvage; date		Piston-satisfactory	•	Fluid clear	clear amber in
		not known;			Pistons-slight scoring		the other two
		12 months +		Secondary cup-moderate		% H ₂ 0-0.5	
				scuffing	Cups-satisfactory		% H ₂ 0-0.6
				Primary cup-moderate	Spring-satisfactory		0.0
				scutting and scoring	D:-L. 7		♦
				Spring-satisfactory	Kight front cylinder— slight stain		
					Pistons—I normal wear, I slight scoring		
					Cups—slight scuffing		
					Spring-satisfactory		
					Left rear cylinder- alight stain		
					Piston-slight scoring		

Cups-slight scuffing Spring-satisfactory

Table 2. Yuma Inspection (Cont'd)

Fluid

Vehicle Number FI and Type 03J43568 (Continued) 1%-Ton

U.C.

TP-593 3D67368 I%-Ton

nœ.	Wheel Cylinders					Fluids clear;	slight sediment	% H ₂ 0-0.2 0 t	0.0	0.0									
bpea	Master Cylinders W					Moderate sediment	% H. 00.0								tac tac				
iion	Wheel Cylinders	Right rear cylinder-slight stain	Pistons-alight scoring	Cups-slight scuffing	Springs-satisfactory	Left front cylinder-	heavy stain in fluid	2	Fistons—slight scoring	Cups-slight scuffing	Spring-satisfactory	Right front cylinder-	slight stain	Pistons—1 slight scoring 1 slight-to-moderate scoring	Cups-moderate scuffing	Spring-satisfactory	Left rear cylinder— small area near bleeder valve shows heavy rust	Pistons-normal wear	Cups-slight scuffing
Visual Indection	Master Cylinders					Cylinder bore-satis-	factory	Piston-satisfactory		Secondary cup—slight scuffing	Primary cup-moderate	scuffing	Spring-satisfactory						
	Mileage					1104													
Inspection Date/	Months of					Apr 75/24													

Spring-satisfactory

Table 2. Yuma Inspection (Cont'd)

Vehicle Number	Fluid	Inspection Date/ Months of	Total	V isual Inspection	pection	Fluid Appearance	rearance.
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
TP-593 (Continued) 3D67368	e e				Right rear cylinder—slight stain		
I%-lon					Pistons-slight scoring		
					Cups-satisfactory		
					Spring-partially detinned	P.	
MS-1 2N1756	U.C.	May 75/24	2629	Cylinder-moderate stain	Left front cylinder- slight stain and wear	Clear	Clear
%-Ton				Pieton _ nestingar	on both ends	% H ₂ 0 0.4	70-0.H% 0.0
•					Pistons-slight stain		0.5
				Secondary cup-slight scuffing	Cups-slight scuffing		†
				Primary cup-moderate	Spring-satisfactory		
				Spring-satisfactory	Right front cylinder- same as left front		
					Left rear cylinder—same as left front		
	:				Right rear cylinder same as left front		
MS-5 2J8403 ½-Ton	U.C.	May 75/24	6463	Cylinder-moderate stain at top of bore	Left front cylinder- slight stain and slight wear both ends	Clear % H _* 0–0.4	Clear % H _* 0-0.3
				Piston-satisfactory		•	0.2
				Cups-satisfactory	Pistons—I slight stain and scoring		e:.0
				Spring-satisfactory	Cups—slight scuffing		

Spring-satisfactory

Table 2. Yuma Inspection (Cont'd)

Vehicle Number	Fluid	Inspection Date/ Months of	Total	Visual In	Visual Inspection	Fluid Appearance	pearance
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
MS-5 (Continued) 2]8403			6317*	Master cylinder and right rear wheel	Right front cylinder- same as left front		
7+1 on				cylinder replaced at 21½ months; parts not returned	Pistons—1 satisfactory; I slight scoring		
					Cups—slight scuffing		
					Spring-satisfact ;		
					Left rear cylinder—same as left front except both pistons show slight scoring		
					Right rear cylinder-slight stain		
					Pistons-satisfactory		
					Cupe-slight scuffing		
					Spring-satisfactory		
MS-25	D.C.	Apr 75/24	4413	Cylinder-satisfactory	Left front cylinder-		Clear
1%-Ton				Piston-satisfactory	fluid area. Slight		% H ₂ 0.0.1
				Secondary cup-severe			0.3
				cracking at base	Pistons I slight scoring; I heavy		0.0
				Primary cup-slight	scoring		
					Cups-satisfactory		
				Spring-satisfactory	Spring-satisfactory		

Right front cylinderslight stain in fluid area

Table 2. Yuma Inspection (Cont'd)

Vehicle Number	Fluid	inspection Date/ Months of	Total	T Leaves V	Visual Inspection	Fluid Appearance	
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders Wheel C	Wheel Cylinders
MS-25 (Continued)					Pistons-normal wear		
1%-Ton					Cups-slight scuffing		
					Spring-satisfactory		
					Left rear cylinderslight stain overall		
					Pistons-normal wear		
					Cups-slight scuffing		
					Spring-satisfactory		
					Left rear cylinder— slight stain overall		
					Piston-normal wear		
					Cups-slight scuffing		
					Spring-satisfactory		
					Right rear cylinder— slight stain in fluid area		
					Pistons I satisfactory I slight scoring		
					Cups-satisfactory		
				i	Spring-satisfactory		
MS-8 I	D.C.	May 75/24	8462	Cylinder-satisfactory	Left front cylinder-	Clear Clear	
%Ton				Piston-satisfactory	scoring in piston area	% H, 0-0,1 % H, 0-1,3	6.1

Table 2. Yuma Inspection (Cont'd)

and Type MS-8 (Continued) 2P8730 %-Ton	Joseph Co.	3	Visual Inspection	ection	Fluid Appearance	or arance
MS-8 (Continued) 2P8730 %-Ton	Newice	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
%-Ton		 - 	Secondary cup-moderate scuffing	Pistons-slight stain		
			Daniel Comment	Cups-slight scuffing		
			scuffing	Spring-satisfactory		
			Spring-s disfactory	Right front cylinderslight stain		
				Piston-slight scoring		
				Cups-satisfactory		
				Spring-satisfactory		
				Right rear cylinder— slight scoring on both ends		
				Pistons—1 slight scoring; 1 slight stain		
				Cups-slight scuffing		
				Spring-satisfactory		
MS-70 D.C. 280799	Jan 75/21	13252	Cylinder-satisfactory	Left front cylinder-	Moderate sediment	Clear
%-Ton			Piston-satisfactory	Distance and and	Fluid clear	% H ₂ 0-0.0
			Secondary cup-slight	scoring	% H ₂ 0-0.3	.
				Cups-slight ecuffing		
			Primary cup-moderate scuffing and scoring	Spring-satisfactory		
			Spring-satisfactory	Right front cylinder—slight stain on both ends		

Table 2. Yuma Inspection (Cont'd)

Vehicle Number	Fluid	Inspection Date/ Months of	Total	Visual Inspection	spection	Fluid Appearance	pearance	
and Type		Service.	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	_	Cylinder
MS-70 (Continued) 2R0799 %-Ton					Pistons—1 slight stain; 1 moderate stain			
					Cups-slight scuffing			
					Spring-satisfactory			
					Left rear cylinder- slight wear both ends			
					Pistons-slight scoring			
					Cups-slight scuffing			
					Spring—detinned			
					Right rear cylinder- spot of corrosion on bottom in fluid area			
					Pistons-moderate stain			
					Cups—slight scuffing			
					Spring -satisfactory			
MS-21 03M+1668 1½-Ton	6.E.	Apr 75/24	11514	Cylinderslight overall rusting	Left front cylinder- alight scoring both ends	Heavy sediment Fluid green	Moderate	
				Piston-satisfactory	Pistons—heavy scoring	7. H, 0–0.8	Fluid amber	t
				Secondary cup-satisfactory	Cups-moderate		% H ₂ 0–0.3 0.9	e 6 -
				Primary cup—slight chipping; 3 blisters	scuring Spring detinned		. T. O	

Right front cylinder-

Spring-detinned

Table 2. Yuma Inspection (Cont'd)

Vehicle Number	F	Inspection Date/ Months of	[ejo]	Visual Instruction	rection	Fluid A birds	7
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
MS-21 (Continued)					slight stain		
1%-Ton					Pistons—I heavy scoring I slight scoring		
					Cups-slight scuffing		
					Spring-detinned		
					Left rear cylinder—slight overall stain; light pitting on one end		
					Pistons I moderate scoring; I light scoring		
					Cups-slight scuffing		
					Spring-detinned		
					Right rear eylinder— moderate scoring on end: slight scoring on other		
					Pistons moderate to heavy scoring		
					Cups—slight scuffing		
					Spring-detinned		
MS-26 03E92768 1%-Ton	G.E.	Apr 75/24	8751	Cylinder-moderate overall rusting in bore	Left front cylinder— slight pitting at one end: other satisfactory	Heavy sediment Fluid black	Moderate-to- heavy sediment
				Piston -satisfactory	Pistons—slight scoring	0 0 0 0 %	Fluid dark amber
				Secondary cup—slight scuffing	I moderate-to-heavy scoring		% H ₂ 0-0.9 1.4
							9.0

Table 2. Yuma Inspection (Cont'd)

	:	Inspection Date/		Visual Inspection	spection	Flud Apprarance	wafahee
Vehicle Number	Fluid	Months of	Nilrage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
MS-26 (Continued)				Primary cup slight	Cups- slight scuffing		
03E92768 1½-Ton				sculling Spring partially	Spring—partially definined		
				detimined	Right front cyli, der slight pitting both ends		
					Pistons - moderate scoring		
					Cups- satisfactory		
					Springdetmned		
					Right rear cylinder- slight scoring one end; other satis-		
					factory		
					Pistons—I heavy scoring; 1 slight-to- moderate scoring		
					Cups satisfactory		
					Spring -satisfactory		
					Left rear cylinder-		
					slight pitting one end: slight scoring		
					both ends		
					Pistons-heavy		
					scoring		
					Cups-satisfactory		
					Spring- detinned		

Table 2. Yuma Inspection (Cont'd)

	:	Inspection Date/	÷	Visital Instanction	er (j. m	Find Appearance	Preparation of
Vehicle Number and Type	Fluid	Months of Service	I otal Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Colinders
MS-3 2F0458	G.E.	May 75/24	9199	Cylinder-slight overall stain	Left front cylinder- slight overall stain	Two drops Clear	
¼-Ton				Piston satisfactory	Pistons- I heavy etch. I slight scoring	'. H30 0.0	
•				Secondary cup—very slight scuffing	Cups slight scuffing		
				Primary cup moderate	Spring detinned		
				to heavy scoring Spring—partially detinned	Right front cylinder moderate stam in fluid area		
					Pistons - normal wear		
					Cups. slight scoring		
					Spring-detinned		
					Left rear cy linder—slight overall stain		
					Pistous-moderate scoring		
					Cups-slight scuffing		
					Spring-detinned		
					Right rear cylinder- slight overall stain		
					Pistons—slight scoring		
					Cupsslight scuffing		
					Spring-detinned		

Table 2. Yuma Inspection (Cont'd)

Fluid

Vehicle Number and Type

MS-7 2J8621 %-Ton

Date/	1.4.	Tribodian Internation	i di	Fluid Appearance	bearance
Months of	i otai Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
Apr 75/24	7599	Cylinder- slight overall stain	Left front cylinder-moderate stain in fluid area	Heavy sediment Sell ₂ 0 0.3	Slight sediment % H ₁ 0 · 0.0
		Piston-satisfactory	Piston-1 moderate		5, 5, 5, 5
		Secondary cup-satisfactory	scorng; I slight scoring Cups—light scuffing		
		Primary cup. slight scuffing	Spring-detinned		
		and scoring Spring—partially detinned	Right front cylinder—moderate to heavy rusting in fluid area and under one piston		
			Piston - 1 slight scoring: 1 moderate scoring		
			Cups—i slight scuffing: I moderate scuffing		
			Spring-de tinned		
			Left rear cylinder-moderate ru † in fluid area		
			Pistons-1 light scoring:		
			Cups-slight scuffing		
			Spring-detinned		
			Right rear cylinder moderate rusting in fluid area		
			Pistons-1 light scoring: I moderate scoring		
			Cups-slight scuffing		
			Spring—detinned		

* Vehicle inspected at one year. New fluid added.

Table 3. Alaska Inspection

The state of the second of the

ance.	Wheel Cylinders	Dark		Moderate	sediment		% H ₁ 0-2.4	6:1	다 . 다	2.0												
Fluid Appearance	Master Cylinders	Dark		% H ₂ 0- 1.1	•																	
tion	Wheel Cylinders	2 cylinders-heavy	corrosion and sludge	in fluid area		I cylinder-moderate	to heavy corrosion;	one spot on side and	top. Heavy spots	under one cup		I cylinder—moderate	in fluid area		3 pistons-normal wear	2 pistons-moderate to heavy scoring	2 pistons—slight scoring	£	1 piston–pitted (13 spots)	2 cups-moderate scuffing and scoring	l cup—moderate scuffing	l cup—slight scuffing and scoring
Visual Inspection	Master Cylinders	Cylinder bore - ring of	corrosion under second-	ary cup.		Overall stain of bore		Piston-heavy corrosion	and stain	Southern and archante	Secondary cup - mountain	scutting	Primary cup-slight scoring	and scuffing. Slight	chipping at base	Springdetinned						
Total	Mileage	3319											•									
Inspection Date/ Months of	Service	Dec 75/12																				
Fluid		MIL.H.	13910																			
Vehicle Number	and Type	L SA03N56068	1%-Fon																			

3 cups—slight scuffing

1 cup-satisfactory

Table 3. Alaska Inspection (Cont'd)

Vehicle Number	Fluid	Inspection Date/ Months of	Total	Visual Inspection	rtion	Fluid Appearance	ratance
and Type		Series.	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
USA03N56068 (Continued) 1%-Ton					2 springs-detinned 2 springs-satisfactory		
2K6108 1'+Ton	L.C.	Apr 75/8	3191	Cylinder bore—satisfactory Piston—satisfactory	All cylinders-slight stain	Slight sediment % H ₂ 0-0.2	Slight sediment % H ₂ 0-0.6
				Spring—satisfactory Secondary cup—slight scuffing	7 pistons-slight stain 1 piston-slight etch All cups-satisfactory		0.3 0.0
				Primary cup-satisfactory	Springs—satisfactory		
2]9248 ½ Ton	U.C.	Apr 75/9	1920	Cylinder bore-satisfactory	All cylinders-slight	Amber	Clear amber
-				Piston-satisfactory	Stalli All victore clinht	Slight sediment	% H ₂ 0−0.3
				Spring-satisfactory	stain	% H ₁ 0-0.5	6 0 0 7 1 9
				Secondary cup- satisfactory	Cups—satisfactory		
				Primary cup—slight scuffing and scoring at base	Aprings—satisfactory		
2]9374 ¼-Ton	t.c.	Apr 75/9	3082	Cylinder bore satisfactory	All cylinders—slight	Slight sediment	Clear
				Piston-satisfactory	All nistons—slight	% H ₂ 0-0.2	% H ₂ 0-0.2 0.2
				Spring-satisfactory	stain		0.0 1.0
				Secondary cup-satisfactory	Cups-satisfactory		
		:		Primary cup—moderate scuffing; slight scuffing	Springs-satisfactory		

Table 3. Alaska Inspection (Cont'd)

		Inspection Date/					
Vehicle Number	Fluid	Months of	Total	Visual Inspection	tion	Fluid Appearance	xearance m.
and Type		-crvice	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	wheel Cylinders
2]9202	D.C.	4pr 75/9	2045	Cylinder bore satisfactory	All cylinders-slight	Clear	Clear
æ <u>7</u> ÷.				Piston-satisfactory		% H ₂ 0-0.2	% H ₁ 0-0.0
				Spring-satisfactory	All pistons—slight stain		0.5 0.2 5.5
				Secondary cup-satisfactory	Cups-satisfactory		
				Primary cup-slight scuffing	Springs-satisfactory		
219490	5.0	Apr 75/9	2000	Cylinder bore - dark ring	2 cylinders-slight	Clear	Clear
				about I inch from push	stain	9, H. 0-0.2	% H. 0-0.0
				roa ena	l cylinder-slight		0.5
				Piston-satisfactory	scoring and stain		0.2
				Spring - satisfactory	l cylinder-slight corrosion one end		?
				Secondary cup-satisfactory	9 nietone slight		
				Primary cup-slight scuffing	stain		
				and chipping	l piston-moderate scoring		
					I piston-heavy scoring		
					l piston–slight scoring		
					l piston—slight to moderate scoring		
					l piston-moderate etch		
					I piston-moderate to heavy etch		

Table 3. Alaska inspection (Cont'd)

				the transfer of the transfer o	ant ar		
		Inspection Date/					
Vehicle Number	Fluid	Months of	Total	Visual Inspection	ction	Finid Apprarance	rafance
and Type		Service	Mileage	Master Cylinders	Wheel Cylinders	Master Cylinders	Wheel Cylinders
2]9490 (Continued)	•				4 cups slight scuffing		
					l cup-moderate scuffing		
					3 cups-satisfactor,		
02H80172 %-Ton	D.C.	Apr 75/9	1206	Cylinder bore - satisfactory	All cylinders-slight	Clear	Clear
				Pistonsatisfactory	All victoric climbs	9 H ₂ 0-0.7	% 11,0 0.6 1.8
				Springsatisfactory	stain		9 — 7
				Secondary cup-satisfactory	7 cups-satisfactory		4.5
				Primary cup-moderate	I cup—slight scoring		
				Scaring and sconing	Springs—satisfactory		

IV. CONCLUSIONS

This program has shown that silicone brake fluid will equal or exceed the performance obtained from current specification fluids in conventional hydraulic brake systems. The water-intolerant silicones show considerably less corrosion than either the conventional fluids or the water-tolerant silicone fluid after the two-year period. After one year in the arctic, both the water-intolerant and the water-tolerant silicones were comparable in performance.

Based on this study and previous laboratory evaluations, silicone brake fluids have demonstrated their potential for use in the bulk of the Army fleet, which is composed of vehicles under 10,000 pounds gross weight and equipped with conventional hydraulic brake systems.

During this test period, however, laboratory tests conducted by a brake parts manufacturer indicated a potential problem with silicone fluids in vacuum over hydraulic brake systems used on vehicles of over 10,000 pounds gross weight. Since the Army fleet includes vehicles with this type of hydraulic brake system, further studies and tests are being conducted to resolve the problem.

The swelling of the rubber cups in the master cylinders of vehicles equipped with the deep-water fording kit can produce brake system failures regardless of the fluid used.

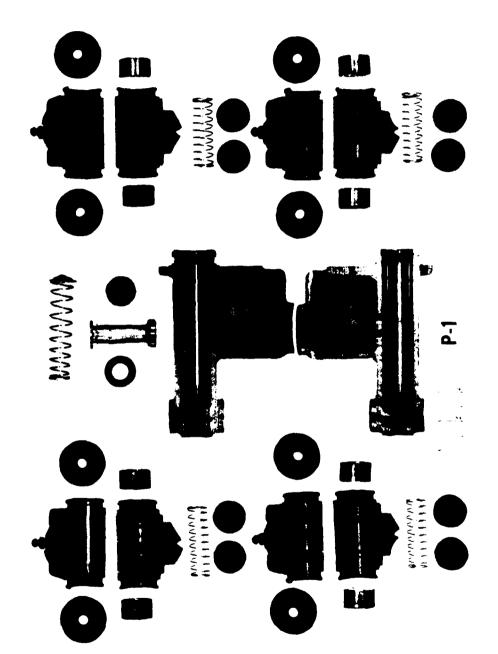


Figure 1. Typical set of cylinders after 2 years' operation at TTC with VV-B-680 fluid.

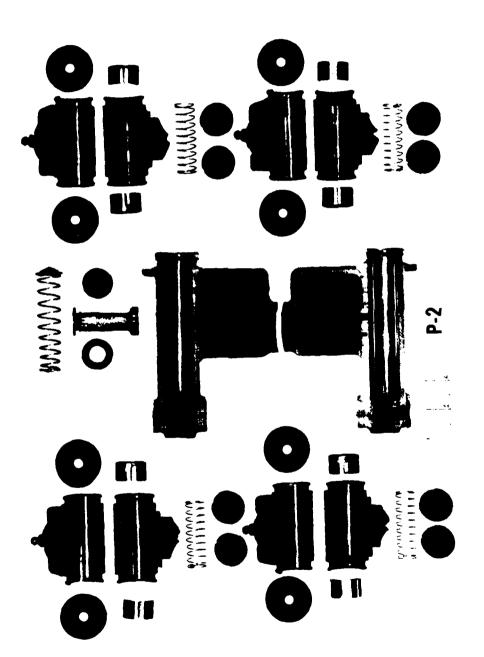
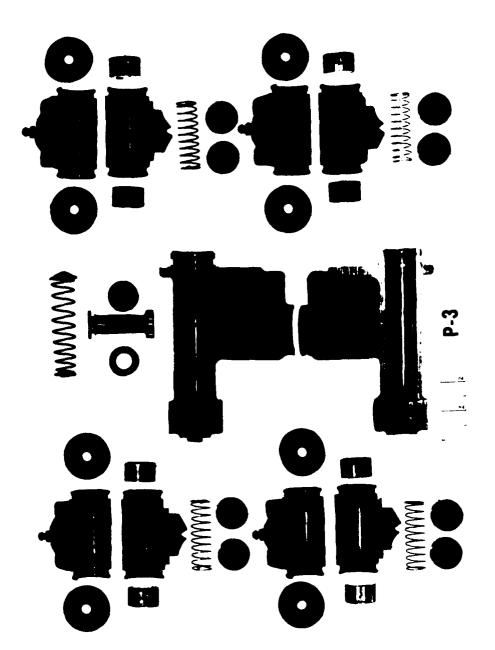


Figure 2. Typical set of cylinders after 2 years' operation at TTC with water-intolerant silicone.



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Figure 3. Typical set of cylinders after 2 years' operation at TTC with weter-tolerant silicone.

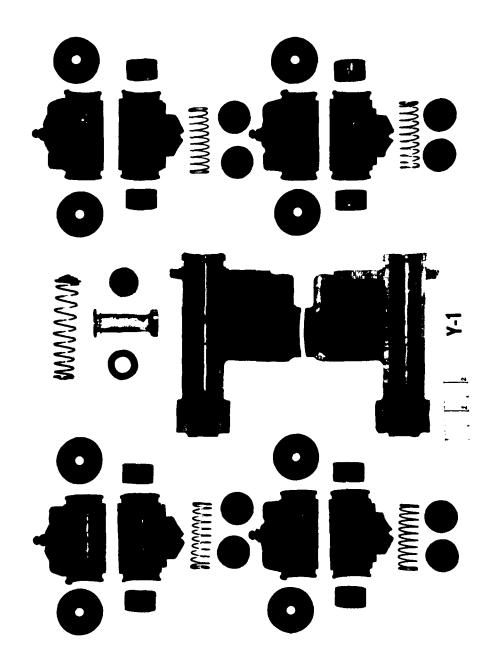


Figure 4. Typical set of cylinders after 2 years' operation at YPG with VV-B-880 fluid.

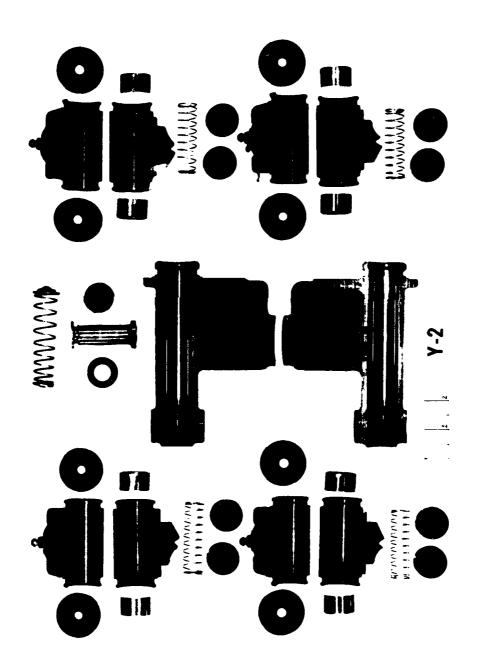


Figure 5. Typical set of cylinders after 2 years' operation at YPG with water-intolerant silicone.

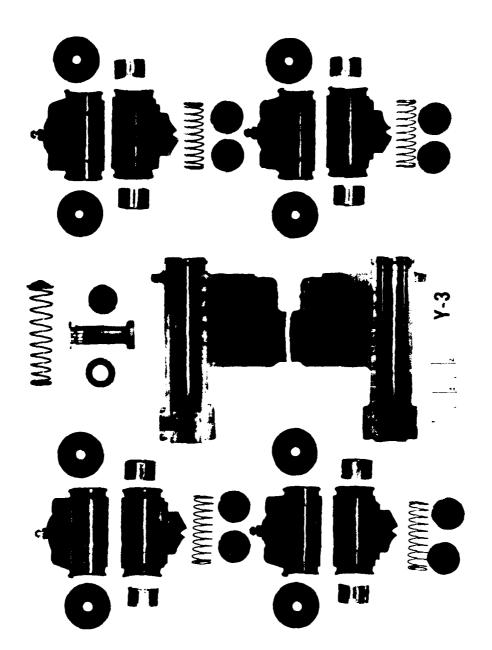


Figure 8. Typical set of cylinders after 2 years' operation at YPG with water-tolerant silicone.

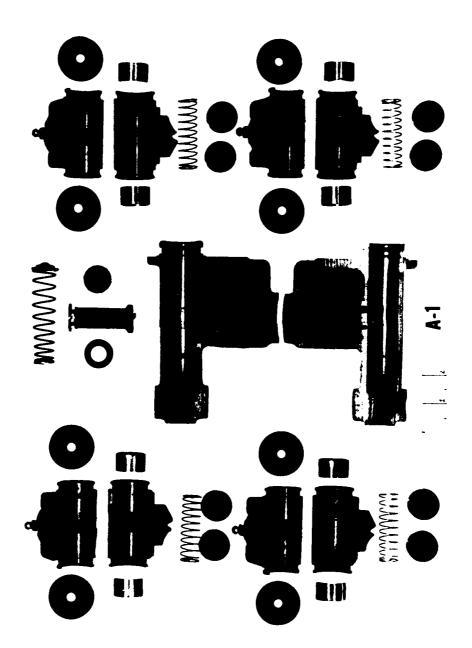


Figure 7. Typical set of cylinders after 1 year's operation at ATC with MIL-H-13910 fluid.

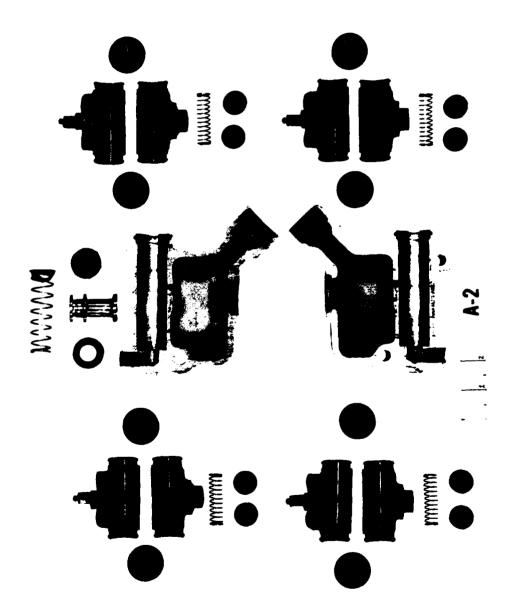


Figure 8. Typical set of cylinders after 1 year's operation at ATC with water-intolerant silicone.

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